US 101 Variable Pricing Study: State Route 37 to the Petaluma River Bridge

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Executive Summary

STUDY BACKGROUND

The purpose of this study is to evaluate the operational and financial feasibility of variable-priced toll lane options on US 101 between SR 37 and the Petaluma River Bridge (an 11.5 mile segment in Marin and Sonoma counties known as the "Novato Narrows") and compare their performance to a base case and conventional HOV lanes.

There are several variable-priced toll lanes operating in the United States; two successful California variable-priced toll facilities, I-15 in San Diego County and SR 91 in Orange County, have been in operation for a few years. These facilities charge tolls to users that vary by time of day, with the highest rates charged during peak commute periods and lower rates charged during off-peak periods; carpools typically are charged a reduced rate or allowed in free.

This is the second study evaluating the feasibility of variable-priced toll lanes in the Sonoma/Marin 101 Corridor. The *Sonoma County US 101 Variable Pricing Study* was completed in January 1999. This study evaluated toll lanes in Sonoma County only, from Petaluma to Windsor (toll lanes south of Petaluma had been considered early on in the study but were dropped to maintain consistency with recommendations from the *Marin/Sonoma Multimodal Transportation/Land Use Study*).

The Sonoma 101 Variable Pricing Study indicated that Sonoma County toll lanes extending from Windsor to SR 116 in Petaluma would provide some congestion management benefits and produce revenue for some operating and capital costs. The potential feasibility of the Sonoma County toll lanes and the continued interest in completing the Novato Narrows segment northward in a reasonable time frame lead to this separate evaluation.

This report evaluates toll lanes as a potential strategy to manage congestion and accelerate implementation of the planned widening between SR 37 and the southern end of the Petaluma River Bridge. This segment of US 101 exhibits traffic characteristics that would appear to make it a good toll lane candidate. For example, the narrows area acts as a gateway with no alternative routes for the large number of commute trips coming from Sonoma County to access jobs in Marin and San Francisco Counties. Furthermore, this segment is often congested throughout parts of the day, similar to the SR 91 and I-15 toll facilities.

STUDY ALTERNATIVES

The study looked at the possibility of constructing either one additional reversible lane or two additional lanes (one in each direction). In total, the study defined five options:

- **Base Case-** No HOV (2005 only)
- **Option A-** Northbound (NB) and Southbound (SB) contiguous HOV Lanes/No Toll (2015 Base Case)
- **Option B-** NB and SB Buffer-Separated Toll/HOV Lanes
- **Option C-** Reversible HOV Lane(s)/No Toll
- **Option D-** Reversible Toll/HOV Lane(s)

The toll lanes would allow carpools with three or more occupants to travel for free; all other vehicles opting to use the lanes would be charged a toll. The new HOV lanes be available for vehicles with 2 or more occupants, consistent with existing HOV lanes in this corridor. The study considers the following additional variations on these alternatives:

- Capital cost variations for all alternatives: (1) Median Widening only – no other improvements (not consistent with freeway standards); (2) Intermediate Widening – median widening with grade separations at selected interchanges and maintaining most existing driveways (not consistent with freeway standards); and (3) Full Freeway Upgrade –interchanges and frontage roads to provide freeway access only at interchanges, per the January 1999 Caltrans Project Study Report (PSR).

- Toll collection systems for the Toll/HOV lane alternatives: (1) electronic toll collection (ETC) system; and (2) permit toll system.

- One versus two reversible HOV or toll lanes: Are there cost savings with a reversible lane and is more than one reversible lane needed? (I-15 uses two reversible toll lanes.)

- Performance of the toll lane in 2015 assuming passenger rail service on the Northwestern Pacific Railroad (NWP) right-of-way.

- Add new HOV lanes or convert existing mixed flow lanes for HOVs between SR 37 and Atherton Avenue? (The Caltrans PSR assess widening only as far south as Atherton Avenue.)

The study analyzed travel demand forecasts for the years 2005 and 2015, capital costs, operations/maintenance (O/M) costs, and operational feasibility of each scenario. For the toll scenarios (Options B and D), the study analyzed the revenue generation, based on travel demand and a variable pricing mechanism that would both optimize revenue and regulate demand, so the lane retains the travel time savings that make it attractive to motorists.

FINDINGS

Effects on Congestion

- *When compared to the Base Case (2005), both the HOV and the HOV/Toll lane options produce significant benefits due to the addition of increased corridor capacity.* When compared to the Base Case, the HOV and HOV/toll lane provide substantial travel time savings to users (approximately 10-12 minutes over the 11.5 miles) and significantly increase person-throughput. Furthermore, the users of HOV and HOV/Toll lanes experience travel time savings of 5 to 7 minutes in 2005 and 4 to 8 minutes in 2015 compared to mixed-flow lanes users. Corridor Vehicle Hours Traveled (VHT) is reduced between 7% and 10% in 2005. Impacts on local roads are minimal because there are few parallel arterials in this section of US 101.
- *There is very little difference in corridor performance between the HOV and HOV/Toll options*. An additional peak direction HOV or toll lane provides sufficient capacity to accommodate projected HOV and mixed flow traffic volumes in 2015. The HOV/toll lanes shift some HOVs with 2 occupants (2+)

traffic to available capacity in the adjacent mixed flow lanes thereby causing mixed flow lane speeds to drop slightly compared to the HOV lane options.
- *There is negligible difference between a time-variable toll rate (tolls change by time of day only) and a time-congestion (tolls change by time of day and toll lane segment).* Performance levels (delay, travel speeds, person-throughput) change less than 1%, which is probably due to the shorter and limited access nature of the alternative.

Concept and Operational Feasibility

- *The toll lane concept is physically and operationally feasible.* The "basic" toll lane project without grade separating critical highway intersections is not recommended due to safety concerns. The intermediate and full freeway widening tolling options are physically and operationally feasible.
- *Upgrading to full freeway standards does not seem to be necessary to operate an effective and safe HOV or toll lane*. The intermediate widening option provides the least expensive alternative that is both safe and operationally sound.
- *There are no significant toll lane ingress/egress issues because there is only one intermediate access point and relatively little on-off traffic at either end or the intermediate access.*
- *Toll collection on this segment of U.S. 101 can be effective and enforceable, using electronic or permit toll collection*. Electronic tolling is more expensive compared to a permit system, but considerably more effective in collecting revenue, enforcement, and managing the freeway to respond to dynamic conditions.
- *There is no advantage to building a single reversible HOV or toll lane.* The capital cost is generally the same because full shoulder widths must be provided, creating the same "footprint" of two directional lanes with narrower shoulders. There are also significant operating costs associated with maintaining a reversible lane.
- *Projected demand does not warrant two reversible lanes.* Three lanes in each direction are sufficient to accommodate projected 2015 peak period traffic volumes.
- *The operations and demand analyses suggest that there would be minimal negative impact associated with converting existing northbound and southbound mixed flow lanes to HOV or HOV/toll lanes between SR 37 and Atherton Avenue*. A more detailed traffic operational analysis needs to be conducted, but travel demand forecasts indicate adequate capacity to accommodate future demand. Furthermore, Caltrans' Novato Narrow's PSR does not address this segment of freeway, thus potentially creating a "gap" in the proposed HOV or toll lane system between Petaluma and Novato. (Widening the Narrows and converting an existing lane between Atherton Avenue and SR 37 for HOVs would provide a continuous 6-lane facility– one HOV and 2 mixed flow lanes in each direction - between the Petaluma River Bridge and SR 37.) This conversion approach would result in cost savings of $17 to $19 million. The lane conversion concept would not be considered for the reversible lane options due to safety considerations.

Financial Feasibility

- *Toll revenues would not likely be sufficient to fully finance toll lane construction and operations*. The 30-year lifetime net revenues, assuming a 6% discount rate, range between $53 million and $55 million. Capital costs for the intermediate widening and full freeway widening range between $86 million and $258 million. Construction of new toll lanes would therefore likely require substantial state and/or local sales tax funding.
- *Toll lane revenues would be sufficient to cover operating and maintenance*

costs. Annual O/M costs are estimated to be $1.5 million. The toll facility generates approximately $1.6 to $1.7 million annually in year 2005. (The variable toll generates the slightly higher amount in this and future years.) By 2015, as a result of demand growth, the facility will generate $2.8 to $2.9 million annually. By the end of its projected 30-year life in 2035, the revenues rise to between $8.1 and $8.3 million. Thus, the facility generates a small net positive cash flow at its opening, up to $1.4 million in 2015, and $6.7 million by 2035.

- *Public policy makers may still deem toll lanes feasible and desirable if other benefits can make it a worthwhile investment.* Those benefits could include: (1) enhanced travel options for motorists; (2) improved traffic flow and system management; (3) increased person-throughput; (4) use of net revenues to offset some portion capital costs, thereby freeing up funds that can be used for other projects.
- *Passenger rail service on the NWP right-of-way had very little impact on toll lane performance and revenue generation*. Toll lane performance measures (VHT, VMT, speeds, etc.) changed less than 1% with rail passenger service added, therefore rail service would have only a negligible impact on revenue generation.

US 101 Variable Pricing Study: SR 37 to the Petaluma River Bridge

Study Background

Marin and Sonoma Counties have had long standing plans to extend US 101 High Occupancy Vehicle (HOV) lanes north from SR 37 in Novato into Sonoma County. The so-called “narrows” area immediately north of Novato experiences severe congestion in the peak commute periods where the highway lanes are reduced from three to two lanes in each direction. The remaining part of the corridor northward to Windsor also experiences varying levels of congestion, with the most severe locations in the Santa Rosa/Rohnert Park area. Local officials have also expressed safety concerns over several at-grade intersections and private driveways between northern Novato and the Petaluma River Bridge and would like to bring this highway segment up to freeway standards.

The Sonoma County Board of Supervisors November 1998 sales tax measure included funds for widening US 101 across the Petaluma River Bridge, south to the Marin/Sonoma County line; the sales tax measure subsequently failed. Though Marin County has also expressed an interest in widening the narrows, the Narrows widening was not included in Marin County’s failed 1998 transportation sales tax measure; the County’s position is that the narrows widening is a State responsibility.

Whether or not sales tax measures are ultimately approved, it is likely that the Novato Narrows segment will not be widened for several years. While the project did receive limited funding in TEA-21 earmarks and Caltrans has begun a Project Study Report (PSR) on the environmental portion of the project, Marin and Sonoma Counties have other higher priority projects. Sonoma County’s US 101 high priority widenings are in the Santa Rosa/Rohnert Park area and Petaluma, north of SR 116 east; the segments south of Petaluma, including widening the Petaluma Bridge, are likely to be lower priority and therefore sales tax funding may not be available until the outer years and in insufficient amounts. MTC’s *1998 Regional Transportation Plan* (RTP) also assumes Interregional Improvement Program funding for HOV lanes between SR 37 and northern Petaluma, but how soon those funds would be available and how much of the total project could be constructed remain in question; new State Transportation Improvement Program (STIP) funding, for example, may not be available until after 2004.

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Widening the Petaluma River Bridge was also excluded from the Sonoma County study due to cost considerations. The Petaluma River Bridge is a high-level, four lane bridge over an environmentally sensitive area. The cost of adding two lanes to the Bridge was estimated to be in the $25 million to 35 million range. Because the area between Petaluma and Novato had earlier been excluded from the study, the Steering Committee did not believe that the high cost of this short section of bridge/roadway would be justified in the alternatives that were retained for further study in Sonoma County.

The recently completed *Sonoma 101 Variable Pricing Study* indicated that Sonoma

County toll lanes extending from Windsor to SR 116 in Petaluma would provide some congestion management benefits and produce revenue for some operating and capital costs. The potential feasibility of the Sonoma County toll lanes and the continued interest in completing the Novato Narrows segment northward in a reasonable time frame lead to this separate evaluation.

This report evaluates toll lanes as a potential strategy to manage congestion and accelerate implementation of the planned widening between SR 37 and the southern end of the Petaluma River Bridge. This segment of US 101 exhibits traffic characteristics that would appear to make it a good toll lane candidate. For example, the narrows area acts as a gateway with no alternative routes for the large number of commute trips coming from Sonoma County to access jobs in Marin and San Francisco Counties. Furthermore, this segment is often congested throughout parts of the day, which makes it similar to SR 91 in Orange County and I-15 in San Diego County, two successful variable-pricing projects implemented in recent years.

Definition of Alternatives

This variable-pricing evaluation considered several alternatives, including a Baseline, HOV and HOV/Toll Lane options. Each of the HOV and toll lane options include three variants: (1) median widening only; (2) intermediate widening, with grade separations at selected interchanges; and (3) full freeway upgrade per the January 1999 Caltrans Project Study Report (PSR).

This study assumes HOV or HOV/ toll lanes would be provided in the section of US 101 from Atherton Avenue through the SR 37 interchange to connect with the existing lanes in Marin County. The Caltrans PSR for adding HOV lanes in the Novato Narrows does not, however, provide for new lanes in the section between Atherton Avenue and the current northern terminus in Marin County, just south of SR 37.

This study uses Options A through D described below to consider the cost and operational feasibility of providing continuity in this section of US 101 by either (1) expanding the existing facility by adding two (or one reversible) HOV or HOV/ toll lane/s or (2) reconfiguring the existing 6-lanes by converting one lane in each direction to an HOV or HOV/ toll lane.

Travel demand forecasts for alternatives were developed for years 2005 and 2015.

<u>Base Case (No Build) Alternative (2005)</u>

The year 2005 Base Case alternative assumes all projects in the 1999 Transportation Improvement Program (TIP). In this case, the Base Case is a true “no build” alternative since the TIP assumes no improvements within the project limits. The HOV service in Marin County ends at SR 37 and the HOV service in Sonoma County runs between Steele Lane and the Rohnert Park Expressway.

Option A – Northbound (NB) and Southbound (SB) Free HOV Lanes (No Toll) (2015 Base Case)

Northbound and southbound HOV lanes would begin just south of the Petaluma River Bridge and extend southward to the State Route 37 interchange in Novato, resulting in a 6-lane facility from Petaluma to Atherton Avenue and an 8-lane facility from Atherton Avenue to SR 37, connecting with the existing HOV lanes at SR 37 (see Figures B & C). There would be no toll component to the HOV lane/s and the lane/s would be available for vehicles with 2 or more occupants. This alternative would serve as the Baseline for the year 2015 since MTC's 1998 Regional Transportation Plan (RTP) provides funding for a continuous facility from northern Petaluma to SR 37.

The HOV lane's physical attributes are consistent with Caltrans' design standards, which include two standard 12-foot lanes in the existing median, with standard 10-foot wide inside shoulders, and a 2-foot wide concrete median barrier. The HOV lanes would be contiguous with the mixed flow lanes, which means no separation other than striping. Users will have continuous access to the new lanes.

Option B - NB and SB Buffer Separated Toll/HOV Lane

Option B is similar to Option A, except that added lanes would be tolled and separated from the mixed flow lanes with a three-foot buffer that includes plastic pylons. The lanes would be free for HOV vehicles with three or more occupants (3+) and have a toll for all other users. See (Figures B and C for the limits in each study year).

The existing highway median has sufficient width to accommodate the two 12-foot wide HOV lanes, standard 10-foot wide inside shoulders, 3-foot wide buffers, and a 2-foot wide concrete median barrier. Users will have limited access to the new lanes. Toll access points will be provided at three points: north of the SR 37 interchange in Novato, north of San Marin Avenue/ Atherton Avenue in Novato, and south of Petaluma Boulevard in Petaluma.

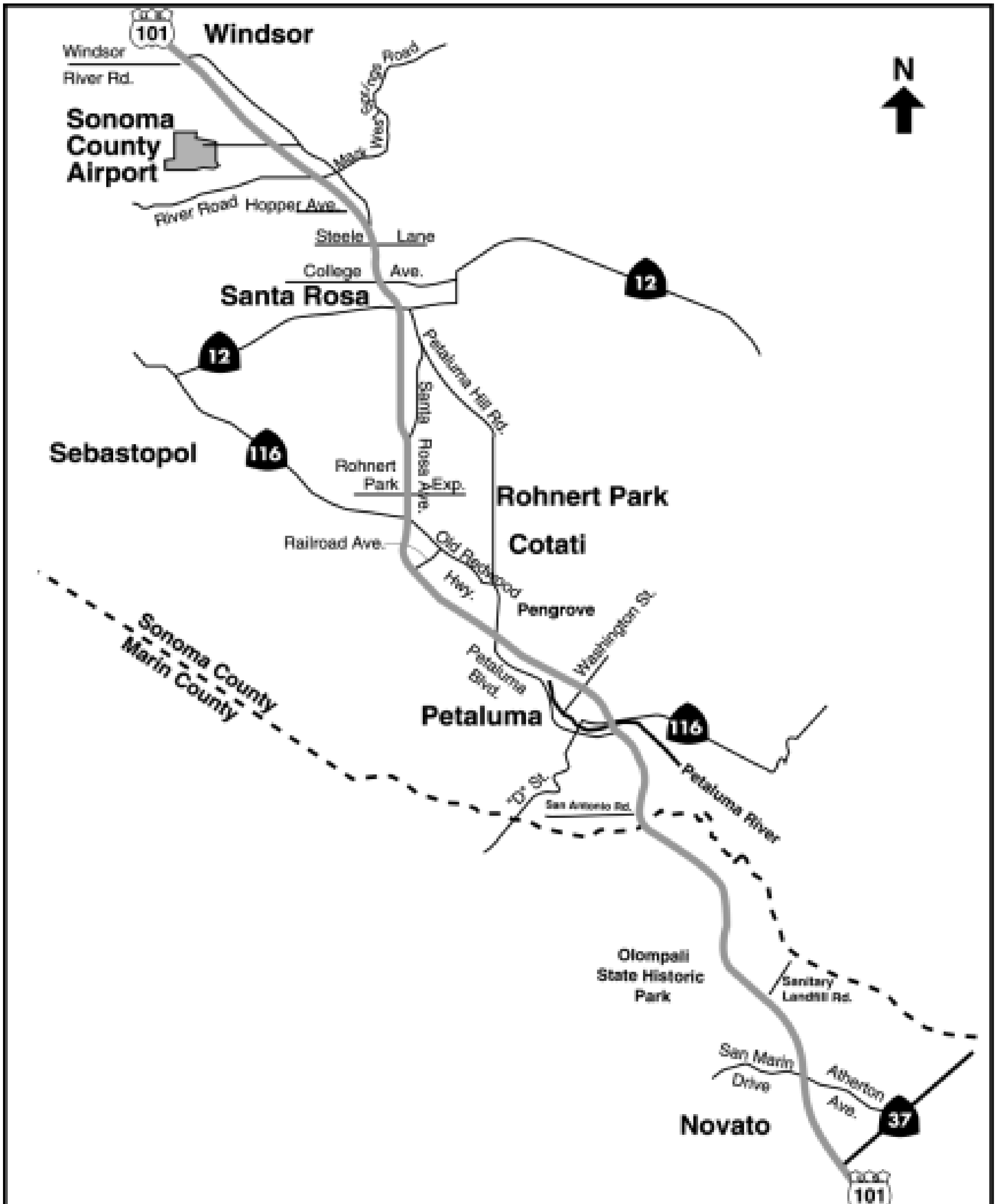
The 2015 analysis will evaluate the impacts of passenger rail operations on the Northwest Pacific Right of Way on toll lane performance and revenue generating potential.

Option C - Reversible Free HOV Lane (No Toll)

Option C consists of providing a reversible HOV lane or lanes on US 101. Demand estimates will determine whether one or two lanes is necessary. The lane/s would be separated from the mixed flow lanes with two, 2-foot wide concrete barriers. The lane/s would accommodate HOV use in the southbound direction for the morning peak and in the northbound direction for the afternoon peak. There would be no toll component to the HOV lane/s and the lane/s would be available for vehicles with 2 or more occupants. (See Figures B and C for the limits in each study year).

The median has sufficient width to accommodate the 12-foot wide HOV lane/s, shoulders, and two 2-foot wide concrete median barriers. The shoulders would range between 2 and 10 feet in width depending on the number of reversible lanes. The HOV

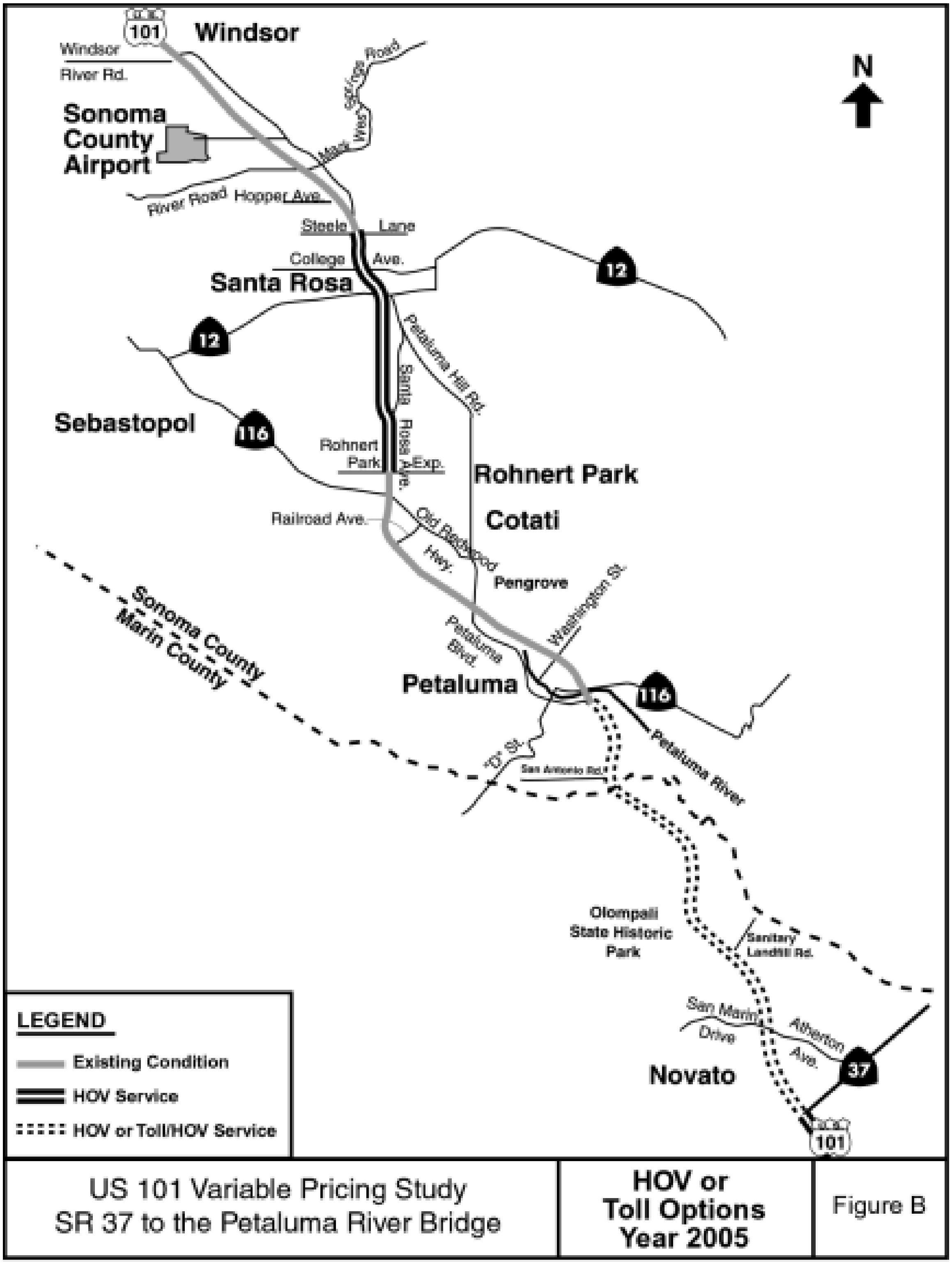
Figure A: Project Location



US 101 Variable Pricing Study SR 37 to the Petaluma River Bridge	**Project Location**	Figure A

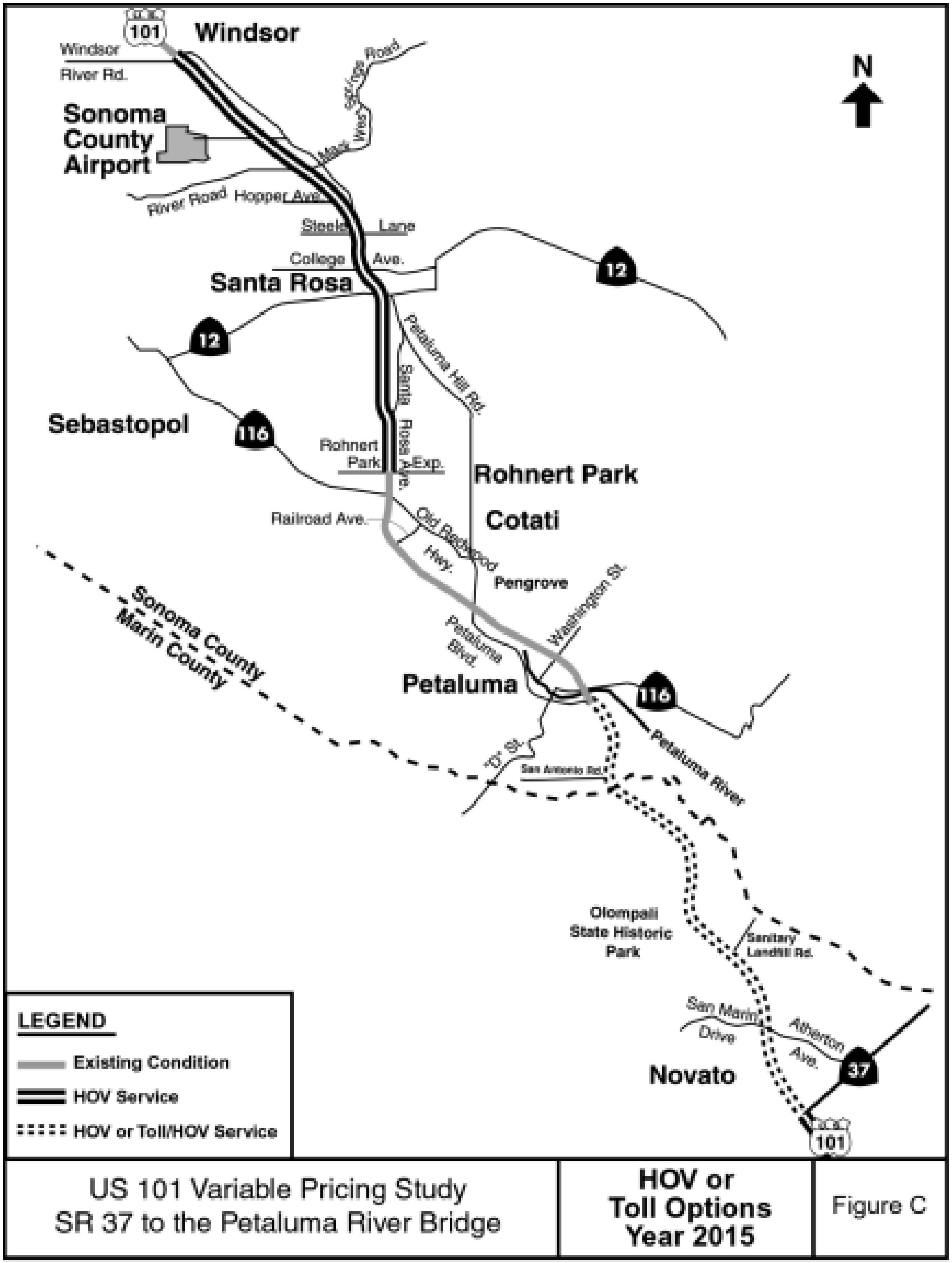
Source: Parsons Brinckerhoff, 1999

Figure B:HOV or Toll Options for Year 2005



Source: Parsons Brinckerhoff, 1999

Figure C: HOV or Toll Options for Year 2015



Source: Parsons Brinckerhoff, 1999

lane/s would be separated from the mixed flow lanes with concrete barriers. The HOV users will have limited access to the new lane/s. Access points will be provided only at the beginning and end of the project limits: north of the SR 37 interchange in Novato and south of Petaluma Boulevard in Petaluma.

The direction of the lanes would be changed twice each day. Reversing the lanes can be done automatically with moveable barriers or manually with plastic pylons.

Option D - Reversible Toll/HOV Lane

Option D is similar to Option C except that the reversible lanes would be tolled as in Option B. The Tolled/HOV users will have limited access to the new lane/s. Toll access points will be provided at two points: north of the SR 37 interchange in Novato and south of Petaluma Boulevard in Petaluma.

Toll Collection and Pricing Structure

Toll Collection Options

The toll lane concept includes two toll collection options: a simple permit system, similar to what was previously used on I-15 toll lanes and electronic toll collection (ETC), similar to what is currently used on I-15 and SR 91 toll lanes, and here in the Bay Area at the Carquinez Bridge toll plaza (and eventually all Bay Area toll bridges).

A permit system would allow a limited number of drivers the opportunity to purchase a windshield-displayed permit for a monthly fee. The permits would allow vehicles with fewer than three occupants to use the HOV lane during peak hours. The obvious advantage of a permit system is its low cost and simplicity. The main disadvantage of the permit system is the difficulty in regulating use; only a limited number can be sold so that demand does not exceed capacity of the toll lane.

The main advantage of ETC is the ability to increase tolls efficiently, according to congestion levels or time of day, and to track and manage violations with a lower on-site police presence. The main disadvantage is increased capital and operating costs.

The toll lanes evaluated in the *Sonoma 101 Variable Pricing Study* were assumed to require electronic toll collection due to the number of access locations desired; a permit system was deemed too difficult to enforce and price due to the varying trip lengths between access locations. Due to the limited access requirements between the Petaluma Bridge and HOV lanes at SR 37, a lower-cost toll lane permit system could be a viable toll collection method.

Pricing Structure

The “time-variable” and “time/congestion” toll structures that were used in the *Sonoma 101 Variable Pricing Study* were also used for this toll analysis. Both toll structures vary by time of day, with the highest toll rates in the most congested periods. Similar to the *Sonoma 101 Variable Pricing Study*, there were 5 rates used: (1) a.m. and p.m. peaks, (2) a.m. and p.m. peak shoulders, (3) mid-day, (4) mid-day weekends and (5) all other times. The time-variable rate tolls each segment the same rate per mile, but varies by time of day. The time/congestion rate not only varies by time of day, but also varies by segment. The segment north of Atherton Avenue, where the highway drops a lane in each direction, was the more congested area and therefore an overall higher toll rate than the southerly segment between Atherton Avenue and SR 37 was used.

Toll rates increased between 2005 and 2015; a higher rate could be charged in the outer years due to a projected increase in corridor congestion. Time-variable rate toll rates varied between 0 and 8.9 cents/mile in 2005, resulting in maximum tolls that range from $0 to $1.02. In 2015, time-variable toll rates grew to a maximum of 9.4 cents/mile. The 2005 time/congestion rate toll varied between 0 and 10.1 cents/mile north of Atherton Avenue and 0.4 to 7.6 cents/mile south of Atherton Avenue, resulting in maximum time-variable tolls that range from $0 to $1.07. In 2015 the maximum time-variable toll declined to 9.8 cents/mile north of Atherton Avenue and increased to 8.9 cents/mile south of Atherton Avenue as further traffic peaking and spreading of the peak periods occur; peak spreading also resulted in an increase off-peak toll rates. As in the *Sonoma 101 Variable Pricing Study*, HOVs with 3 or more occupants were allowed free use of the toll lane.

Table 1: Proposed Toll Rates (cents/mile) **2005**

Toll Period	A.M. and P.M. Peaks	A.M.. and P.M. Peak Shoulders	Mid-Day	Mid-day Weekends	All Other Times
Freeway Section		Time-	Congestion		
N. of Atherton	10.1	4.3	0.8	0.5	0.0
N. of SR 37	7.6	3.8	1.6	0.7	0.4
		Time-	Variable		
All Links	8.9	4.0	1.1	0.6	0.0

2015

	A.M. and P.M. Peaks	A.M.. and P.M. Peak Shoulders	Mid-Day	Mid-day Weekends	All Other Times
Freeway Section		Time-	Congestion		
N. of Atherton	9.8	7.7	2.4	1.4	0.0
N. of SR 37	8.9	7.2	3.0	1.5	0.4
		Time-	Variable		
All Links	9.4	7.4	2.6	1.4	0.0

Travel Demand Forecast Results

The methodology and evaluation of the Novato Narrows options followed the same procedure as in the *Sonoma 101 Variable Pricing Study* of June 1998. The travel/revenue forecasting uses an iterative approach that combines two processes: (1) travel demand forecasts using an enhanced version of the MTC Model, and (2) a toll/revenue and toll lane speed maximizing procedure. The travel demand forecasts develop estimated toll and mixed-flow lane traffic volumes. The toll/revenue procedure uses the traffic forecasts to evaluate various toll pricing structures and toll levels and attempts to maximize the revenues and toll lanes speeds. This process produces refined toll lane volumes and speeds and annual revenue estimates for optimized toll rates for the toll lane alternative.

The key travel forecasting results are shown in tables on the following pages. Table 2 includes corridor statistics on freeway toll lane and mixed flow lane vehicle-miles traveled (VMT) and vehicle-hours-traveled (VHT), corridor speeds, travel times and person throughput for all options for 2005 and 2015 conditions. Table 3 compares travel statistics between options. Tables included in the Appendix show individual AM Peak hour segment statistics, including peak hour volume, speed, travel time, volume/ capacity ratio (V/C), VMT, VHT and Person Throughput for southbound travel on SR 101. In order to capture statistics for local roads, the study area extends out to the east and west adjacent to the SR 101 freeway within the project limits.

Comparison of Options:

Comparison of 2005 Base Case and Option A (NB and SB contiguous HOV Lanes/No toll)
The statistics from Tables 2 and 3 show that during the AM peak hour, corridor VMT would increase slightly in Option A (Free HOV lanes) compared to the Base Case (1,443 vehicle-miles or 0.9% in 2005). Total VHT in Option A, as measured in vehicle-hours traveled, declines significantly by 633 vehicle-hours, or about 10% less than the Base Case in 2005. Average vehicle speeds also improve significantly in Option A, with freeway mixed-flow lanes improving from 30.6 mph to 40.1 mph for the HOV option, while the HOV lane operates at around 55 mph.

The comparison in Table 3 between the Base Case and HOV Option A yields these results: an increase in freeway road capacity tends to increase the VMT on the freeway links, while reducing the delay or VHT. VMT increases in Option A because the added capacity of the HOV lane reduces mixed-flow lane impedance, improves corridor speeds, and therefore moves more people per hour through the corridor (person throughput) and facilitates more auto trips on the freeway. VMT on the local roads and the freeway mixed-flow lanes is reduced compared to the Base Case, with the increase being carried by the HOV facility.

Average travel times over the full 11.5 mile length of the facility are about 5.8 minutes faster in the mixed-flow lanes in the HOV Option A compared to the Base Case; this produces a person throughput increase of about 15%. Travel in the HOV lane in Option A represents an even greater time saving of 10.7 minutes compared to travel in the mixed flow lanes in the Base Case. These results reflect Option A's areawide

Table 2: SR 101 Corridor VMT, VHT, Average Travel Times and Person Throughput

Table 2

SR 101 Corridor VMT, VHT, Average Speed and Travel Times and Person Throughput

Southbound AM Peak Hour Conditions

	Time-Variable (Flat per mile) Toll				Time/Congestion (Variable) Toll			
Alternative	Local Roads	Freeway Mixed-Flow	Freeway HOV/Toll	Total	Local Roads	Freeway Mixed-Flow	Freeway HOV/Toll	***TOTAL***
	Vehicle-Miles Traveled (VMT)				Vehicle-Miles Traveled (VMT)			
2005								
Base Case	103,376	56,806	0	160,182	103,376	56,806	0	160,182
Option A - HOV	101,666	48,435	11,524	161,625	101,666	48,435	11,524	161,625
Option B - Toll	101,658	51,439	9,881	162,978	101,658	51,639	9,697	162,994
2015								
Option A - HOV	103,011	47,491	13,047	163,549	103,011	47,491	13,047	163,549
Option B - Toll	102,884	52,150	9,821	164,855	102,884	52,222	9,754	164,860
Option B - Toll with Rail	102,370	51,368	9,723	163,460	102,370	51,439	9,656	163,465
	Vehicle-Hours Traveled (VHT)				Vehicle-Hours Traveled (VHT)			
2005								
Base Case	4,670	1,858	0	6,528	4,670	1,858	0	6,528
Option A - HOV	4,476	1,208	211	5,895	4,476	1,208	211	5,895
Option B - Toll	4,501	1,376	169	6,046	4,501	1,397	166	6,064
2015								
Option A - HOV	4,915	1,155	247	6,317	4,915	1,155	247	6,317
Option B - Toll	4,902	1,421	168	6,491	4,902	1,411	167	6,480
Option B - Toll with Rail	4,877	1,400	166	6,443	4,877	1,390	165	6,433
	Average Speed (MPH)				Average Speed (MPH)			
2005								
Base Case	22.1	30.6	0.0		22.1	30.6	0.0	
Option A - HOV	22.7	40.1	54.6		22.7	40.1	54.6	
Option B - Toll	22.6	37.4	58.5		22.6	37.0	58.4	
2015								
Option A - HOV	21.0	41.1	52.8		21.0	41.1	52.8	
Option B - Toll	21.0	36.7	58.5		21.0	37.0	58.4	
Option B - Toll with Rail	21.0	36.7	58.5		21.0	37.0	58.4	
	Travel Time (Minutes)**				Travel Time (Minutes)**			
2005								
Base Case	33.6	24.3	0.0		33.6	24.3	0.0	
Option A - HOV	32.8	18.6	13.6		32.8	18.6	13.6	
Option B - Toll	32.9	19.9	12.7		32.9	20.1	12.7	
2015								
Option A - HOV	35.5	18.1	14.1		35.5	18.1	14.1	
Option B - Toll	35.4	20.3	12.7		35.4	20.1	12.7	
Option B - Toll with Rail	35.4	20.3	12.7		35.4	20.1	12.7	
	Freeway Person Throughput				Freeway Person Throughput			
2005								
Base Case		16,351	0	16,351		16,351	0	16,351
Option A - HOV		14,084	4,681	18,765		14,084	4,681	18,765
Option B - Toll		15,536	2,643	18,179		15,466	2,735	18,201
2015								
Option A - HOV		14,015	5,242	19,257		14,015	5,242	19,257
Option B - Toll		15,739	2,744	18,483		15,718	2,772	18,490
Option B - Toll with Rail		15,503	2,717	18,219		15,482	2,744	18,227

** 1) Travel Time is measured from Petaluma River to SR 37; 2) AM Peak Hour occurs between 7:30am and 8:30am
3) Only Option B varies by flat vs variable toll structure; 4) Options C&D (Reversible HOV is same as Options A&B)

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Table 3: Comparison of Options

Table 3: Comparison of Options

HOV Lane Option compared to Base Case

Alternative	Toll Structure	Corridor VMT	Corridor VHT	Speed Mixed Lane (mph)	Speed HOV Lane (mph)	Travel Time Mixed (minutes)	Travel Time HOV (minutes)	Person Throughput
2005								
Option A -HOV	HOV 2,3+ free	+ 0.90%	- 9.7%	+9.5	+24.0	- 5.8	- 10.7	+ 14.8%
2015								
Option A -HOV	HOV 2,3+ free	+ 2.10%	- 3.2%	+10.5	+22.2	- 6.2	- 10.2	+ 17.8%

Toll Lane Option compared to Base Case

Alternative	Toll Structure	Corridor VMT	Corridor VHT	Speed Mixed Lane (mph)	Speed Toll Lane (mph)	Travel Time Mixed (minutes)	Travel Time Toll (minutes)	Person Throughput
2005								
Option B -Toll	Time-Variable	+ 1.75%	- 7.4%	+6.8	+27.9	- 4.4	- 11.6	+ 11.2%
Option B -Toll	Time/Congestion	+ 1.76%	-7.1%	+6.4	+27.8	- 4.2	- 11.6	+ 11.3%
2015								
Option B -Toll	Time-Variable	+ 2.92%	- 0.57%	+6.1	+27.9	- 4.1	- 11.6	+ 13.0%
Option B -Toll	Time/Congestion	+ 2.92%	-0.49%	+6.0	+27.8	- 4.0	- 11.6	+ 13.1%

Comparison of Toll Lane Pricing Structure

Alternative	Toll Structure	Corridor VMT	Corridor VHT	Speed Mixed Lane (mph)	Speed Toll Lane (mph)	Travel Time Mixed (minutes)	Travel Time Toll (minutes)	Person Throughput
2005								
Option B -Toll	Time-Variable	0	0	0	0	0	0	0
Option B -Toll	Time/Congestion	no change	no change	- 0.4	+ 0.1	+ 0.2	no change	+ 0.1%
2015								
Option B -Toll	Time-Variable	0	0	0	0	0	0	0
Option B -Toll	Time/Congestion	no change	no change	- 0.1	+ 0.3	-0.2	no change	+ 0.1%

Toll Lane Option compared to HOV Lane Option

Alternative	Toll Structure	Corridor VMT	Corridor VHT	Speed Mixed Lane (mph)	Speed Toll Lane (mph)	Travel Time Mixed (minutes)	Travel Time Toll (minutes)	Person Throughput
2005								
Option B -Toll	Time-Variable	+ 0.83%	+ 2.5%	-2.7	+3.9	+1.3	- 0.9	- 3.2%
Option B -Toll	Time/Congestion	+ 0.84%	+ 2.8%	-3.1	+3.8	+1.5	- 0.9	- 3.1%
2015								
Option B -Toll	Time-Variable	+ 0.80%	+ 2.7%	-4.4	+5.7	+2.2	- 1.4	- 4.2%
Option B -Toll	Time/Congestion	+ 0.80%	+2.7%	-4.5	+6.0	+2.2	- 1.4	- 4.2%

Toll Lane with Rail compared to Toll Lane without Rail

Alternative	Toll Structure	Corridor VMT	Corridor VHT	Speed Mixed Lane (mph)	Speed Toll Lane (mph)	Travel Time Mixed (minutes)	Travel Time Toll (minutes)	Person Throughput
2005								
n/a								
n/a								
2015								
Option B -Toll with Rail	Time-Variable	- 0.85%	- 0.75%	no change	no change	no change	no change	- 1.45%
Option B -Toll with Rail	Time/Congestion	- 0.85%	- 0.95%	no change	no change	no change	no change	- 1.44%

performance improvement with respect to VMT, VHT, person-throughput, average speeds and travel times during the key AM peak and PM peak hours of travel.

Comparison of 2005 Base Case and Option B (NB and SB Toll/HOV Lanes)

The results from Tables 2 and 3 show that during the southbound AM peak hour, corridor VMT would increase slightly in Option B compared to the Base Case (about 2,800 vehicle-miles or 1.8% in 2005). Total VHT in Option B declines by between 464 and 482 vehicle-hours, or about 8% in 2005, compared with the Base Case. Average vehicle speeds in mixed-flow lanes improve from 30.6 mph to 37.4 mph with Option B, while toll lane speeds operate at around 59 mph.

The comparison in Table 3 between the Base Case and Option B yields these results: the increase in freeway road capacity with Option B tends to increase the VMT on the freeway links, while reducing the delay or VHT. VMT increases because the added capacity of the HOV/Toll lane reduces mixed-flow lane impedance, improves corridor speeds, and therefore moves more people per hour through the corridor (person throughput) and facilitates more auto trips on the freeway. VMT on the local roads and the freeway mixed-flow lanes is reduced compared to the Base Case, with the increase being carried by the HOV/toll facility.

Average travel times in Option B over the full 11.5 mile length of the facility are about 4.4 minutes faster than the Base Case in the mixed-flow lanes. This provides a person throughput increase of about 11%. The Option B's HOV/toll lane represents an even greater time saving of 11.6 minutes compared to travel in the mixed flow lanes in the Base Case. These results reflect an areawide performance improvement with respect to VMT, VHT, person-throughput, average speeds and travel times during the key AM peak and PM peak hours of travel.

Comparison of HOV Option A and Toll Option B

The HOV (Option A) and HOV/Toll (Option B) proposals have different operating strategies, as follows: For Option A, single vehicle occupants are prohibited, while 2-person and 3+ person carpools are permitted free. For Option B, single vehicle and 2-person occupants are permitted with a toll charge, while 3+ person carpools are permitted free. Although they operate differently with respect to 2-person carpools, the corridor results indicate only minor differences between Option A and Option B for both 2005 and 2015. As shown in Tables 2 and 3, total corridor VMT in Option B is only marginally higher than Option A, by 1,353 vehicle-miles, (0.8%) in 2005 and by 1,306 (0.8%) in 2015. However due to their different operating strategies, there is greater variation among the lane types between the two Options. In the mixed-flow lanes, VMT in Option B is higher (by 3,004 vehicle-miles or 6.2%) in 2005, and 4,659 vehicle-miles (9.8%) in 2015) compared to Option A, while the corresponding VMT in Option B is less (1,643 vehicle-miles (14.3%) in 2005, and 3,226 vehicle-miles (24%) in 2015) than in Option A.

In 2005, the Toll lane in Option B operates at a higher speed than the HOV lane in Option A (58.5 mph vs. 54.6 mph), while the mixed-flow lanes in Option B are slightly slower (37.4 mph compared to 40.1 mph) in Option A. Option A also has a slightly higher person throughput (3%) than the toll Option B. This speed and VMT benefit is a function of the ability to optimize the toll charged in the toll facility of Option B and still maintain a higher operating speed in the Toll lane. This is not the case for the HOV lane in Option A, where the only criterion for use is that vehicles have two or more occupants.

Comparison of Time-Variable and Time/Congestion Toll Rates in Option B

The previous 1998 *Sonoma 101 Variable Pricing Study* found significant differences in corridor performance between time-variable (flat per mile rate) and time/congestion (variable per segment rate) toll rates for the various alternatives evaluated. Those differences were due to the widely varying levels of congested segments within the Sonoma County corridor. For the Novato Narrows, however, corridor performance measures do not change much with the variation of toll structure (see Table 3) in Option B. This is likely due to the shorter length and limited access nature of the toll facility in this corridor.

Comparison of Toll Option B (without Rail) and Option B (with Rail)

The effect of adding the rail network in 2015 to Option B is to reduce total corridor VMT and VHT by less than 1%. The resulting effect on travel speed and time is minimal.

The focus of this study was to assess toll lane feasibility, and therefore the study did not directly analyze the impact of toll lanes on forecasted rail ridership on service on the Northwestern Pacific right-of-way in the US 101 Corridor. Based on experience with other corridor alternative analyses and interpretation of the study results, it is likely that either free HOV or toll/HOV lanes would reduce potential rail ridership. As indicated by Table 2, the additional capacity provided by the HOV and toll lane options provide a significant travel time savings for both the mixed flow lanes (5 to 6 minutes) and the restricted HOV or toll lanes (11 to 12 minutes) compared to the 2005 No Build or Base Case scenarios. The travel time savings would likely divert a portion of potential riders from the rail system to the highway as either carpools or drive-alone.

Performance of Option C (Reversible HOV Lane/No Toll)

The analysis considered a reversible HOV lane facility on SR 101 in Option C. In this option, the HOV lane would only be available for peak-direction travel (southbound in the AM and northbound in the PM). This HOV lane would be reversed from southbound-only travel in the morning to northbound in the afternoon. There is no difference in corridor statistics in the peak direction between Option C and Option A, and only a minor effect in the non-peak direction. (The forecasts for Option A for the 2-way HOV facility indicate a northbound AM Peak HOV lane volume of 362 vph in 2005, and 380 vph in 2015.) For Option C, since there would be no northbound HOV lane in the AM peak, the northbound HOV vehicles would be diverted back into the mixed flow lanes, increasing traffic levels by a marginal amount (from 970 vph per lane to 1,140 vph per lane in 2005 and from 980 vph to 1,150 vph in 2015).. Furthermore the demand indicates the corridor only needs a single reversible HOV lane.

Performance of Option D (Reversible HOV/Toll Lane)

As with the reversible HOV lanes, the operating characteristics of the reversible toll lane are similar to the NB/SB toll lanes. There is no effect of this reversible lane on corridor statistics in the peak direction and only negligible effect in the non-peak direction (the forecasts for Option B for the 2-way Toll facility indicate a northbound AM Peak Toll lane volume of 217 vph in 2005 and 225 vph in 2015). So for Option D, these northbound tolled vehicles would remain “un-tolled” and would have to use the mixed flow lanes, increasing traffic levels by a marginal amount. Toll lane demand also indicates the corridor only needs a single reversible Toll/HOV lane.

Performance of the Local Arterial Road Network

The local arterial network includes all local roads within about 3 miles of US 101 up to the Petaluma River Bridge and SR 37; most of these local roads are in the Novato area and have a minor impact on freeway diversion. Table 2 shows that the toll lane Option B marginally improves the performance of corridor local roads compared to the

Base Case. Option B VMT in 2005 is reduced by 1,718 vehicle-miles (1.7%) compared to the Base Case, while VHT reduces by 169 vehicle-hours (3.6%). The resulting average speed on the local roads in the corridor improves only slightly from 22.1 mph to 22.6 mph with the toll lane. The benefit to local roads in 2015 is minimal when compared to the 2005 Base Case, largely because of the higher ambient traffic levels on local arterials in Novato in 2015.

The marginal impacts of the HOV and toll lanes on the performance of the local roads reflect the fact that that there are no real parallel alternatives to SR 101 in this part of the corridor and therefore not much diversion occurs when the highway is widened.

Conclusions from Travel Forecasting

1. Comparison of Base Case to HOV and Toll (2005)
   - HOV and toll options improve speeds in the mixed-flow lanes because:
     - The HOV option shifts HOV 2-person and 3+ person carpools to the HOV lane from the mixed flow lanes.
     - The toll lane options shift some of the HOV and drive-alone vehicles to the toll lane from the mixed flow lanes, though fewer total vehicles are shifted than under the HOV option.
   - The HOV and Toll options both reduce travel times in the corridor; however, the toll options result in a smaller improvement in mixed flow speeds than the HOV option. (In 2005 the difference between the two alternatives in mixed flow travel time is only about 1 minute over the 11.5 mile segment.)
   - The HOV and Toll options increase vehicle and person throughput in the corridor compared to the Base Case.
   - The addition of an HOV or toll lane slightly increases freeway corridor VMT, while slightly reducing VHT.
   - The addition of an HOV or toll lane only slightly reduces VMT and VHT on local roads due to the lack of good parallel routes.

2. Comparison of Toll to HOV
   - Compared to the toll options, the HOV option results in somewhat higher speeds in the mixed flow lanes and lower speeds in the restricted lane (HOV or toll lane). In 2015, the difference between the options in travel time in the mixed flow lane is approximately 2.0 minutes over the 11.5 mile segment. The difference in the restricted lane is also approximately 2 minutes.
   - The toll lane attracts some single occupancy vehicles, but mostly shifts HOV 2+ into the mixed flow lanes, which increases toll lane speeds but reduces mixed flow lanes speeds compared to the free HOV lane options.

3. Comparison of a Single Reversible HOV/Toll lane with One HOV/Toll Lane in Each Direction
   - The reversible HOV and HOV/Toll lane options do not appreciably reduce traffic service levels in the non-peak direction, compared to the option of one HOV or HOV/Toll lane in each direction.

   - Based on the projected demand for 2015, the corridor only needs a single reversible HOV lane or single HOV/Toll Lane to accommodate peak traffic volumes.

4. Comparison of Toll Structure

- The variation in toll structure does not affect system performance much, while only slightly improving revenues.

5. Comparison of Toll with and without Rail
   - The addition of the rail network in 2015 only marginally improves corridor VMT and VHT under the Toll option.

Operations Assessment

Each of the options considered has unique operational characteristics. The characteristics discussed here are the traffic operational characteristics of adding a new HOV or toll lane (bi-directional or reversible) assuming median only widening, intermediate widening and full freeway widening variants. The type of toll collection system (permit or automated) is assumed to have no significant impact on traffic operations.

Median Widening Only
This level limits the physical improvements to widening the existing median only. There will be no adverse operational impact for the freeway segment between Route 37 and Atherton Avenue. Access to U.S. 101 is provided through three grade-separated interchanges; Rowland Boulevard, DeLong Avenue and Atherton Avenue/San Marin Drive. The proposed HOV lanes will operate like the existing HOV lanes in Marin County where no operational problems exist.

The conventional highway segment from Atherton Avenue to Petaluma Boulevard will not be upgraded to a freeway under this level of improvement. The at-grade access driveways would remain. The driveways in this segment allow access to one direction of U.S. 101 only. The vehicles are not allowed to cross the highway. However, there are several intersections where access is allowed across the highway. The three at-grade crossings are at the Sanitary Landfill, San Antonio Road and Kastania Road. Drivers entering US 101 from the driveways use these intersections to make U-turns.

These at-grade crossings of U.S. 101 present a number of significant operational and safety concerns. With the current configuration of U.S. 101, the cross traffic must cross two lanes of highway traffic. Widening the median and providing HOV or toll lanes and a less congested facility create a potential safety hazard for crossing traffic. Additional lanes increase the distance a vehicle must travel through opposing traffic. Also, the highway traffic will now be traveling at different speeds. The travel demand forecasts indicate that the HOV lanes will be traveling 15 mph faster than the mixed flow lanes. The varying speeds will make it difficult for vehicles to evaluate an appropriate gap to cross the highway. Finally, the concrete median barrier that would be installed would obstruct driver vision when attempting to cross the highway. For these reasons none of the widening-only options are not recommend.

It should also be noted that there are no other high-speed HOV or toll lanes in existence where at-grade crossings are allowed. There may be other safety issues that have not been raised above.

Widening with Grade-Separated Interchanges
This level is similar to the “widening only” option because it limits the widening of U.S. 101 to the median only. However, it also includes providing three grade-separated interchanges at Sanitary Landfill Road, San Antonio Road and Kastania Road. The segment of the corridor from Atherton Avenue to Petaluma Boulevard would not be upgraded to a freeway because the intermediate driveways would remain.

The interchanges provide a safe means for traffic to cross the highway. The intermediate driveways would remain to allow access to and from the adjoining properties. These driveways provide access to and from these adjoining properties in one direction only. The impact of the traffic entering and exiting at these driveways would remain.

The intermediate driveways can have an adverse operational impact to the corridor, but they are infrequently used and pose no significant safety hazard. Traffic entering from or exiting to these driveways impacts the speed of the highway. Many of the driveways have acceleration and deceleration lanes; however, they do not allow the vehicles to match the speed of the highway. Driveway operational impacts can be mitigated by providing longer deceleration and acceleration lanes.

The intermediate widening improvements are aimed at providing the least costly option while providing a safe facility.

<u>Full Freeway</u>
This level of improvement alters the U.S. 101 corridor dramatically. This option upgrades the conventional highway segment to a freeway with full control of access at the interchanges. Caltrans studied the full freeway options for their Project Study Report approved in January 1999. The full freeway requires that the driveways be cut off from the freeway. The improvements include converting the existing southbound lanes to a frontage road, shifting the entire corridor to the east, and providing grade-separated interchanges. This level of improvement eliminates the operational and safety issues present in the widening only and intermediate widening options.

<u>Reversible Lanes</u>
The intermediate access north of Atherton Avenue cannot be provided due to the operational and safety concerns associated with providing a gap in the reversible facility. A gap would create the possibility that traffic would attempt to access the HOV Lane/s at the wrong time of day and/or enter in the wring direction and face oncoming traffic. Such practice is not applied on any reversible facility in the U.S. For this reason, widening only option would not be feasible with the reversible lane options because highway intersections would need to be grade separated.

<u>Lane Conversion Concept: SR 37 to Atherton Avenue</u>
Each of the four Options assumes that pavement widening will be used to provide the HOV lanes. However, analysis of the projected traffic volumes for the freeway segment from Route 37 to north of Atherton Avenue indicates that two of the current lanes could be converted to contiguous HOV lanes while maintaining acceptable level of service for the remaining mixed flow lanes. Widening of U.S. 101 at the U.S. 101/Route 37 Interchange would, however, be required. The lane conversion concept could be considered for Options A and B, but not Options C and D. The safety requirements of the reversible lane(s) require additional pavement width.

The lane conversion concept would result in a 6-lane freeway corridor from Rowland Boulevard to Petaluma Boulevard, a distance of approximately 11 miles. The most congested portion of U.S. 101 within the existing freeway segment would be at the Rowland Boulevard Interchange. The peak period volumes on U.S. 101 at Rowland Boulevard would be approximately 2,000 vehicles per lane (vpl) for the mixed flow lanes and 1,150 vpl for the HOV lane. These volumes represent a congested condition but an acceptable service level. A more detailed analysis should be conducted to ensure operational feasibility.

Cost Estimates

Preliminary capital and operations and maintenance (O&M) cost estimates were developed for each of the options. Below is a general description of each element of the costs. Following that discussion is a description of the costs for each of the options under study.

Capital Costs

Capital cost estimates were developed using the Caltrans' Preparation Guidelines for Project Development Cost Estimates from the Project Development Procedures Manual. The estimates are divided into four categories:

- Roadway Items
- Structure Items
- Right of Way
- Design and Construction Engineering

The Roadway, Structure, and Right of Way estimates were prepared by reviewing "as-built" plans and aerial mapping for U.S. 101. The Roadway Items include fundamental items for earthwork, pavement, drainage, signing and striping. For options that include toll collection, items such as video cameras, automatic vehicle identification (AVI) system used for toll collection, changeable message signs, fiber optic cables to carry data, a central control room and vehicle transponders may be included. The cost for additional barriers and gates for reversible operations are included with the roadway items for those options.

Capital costs for Options A through D have been developed for the three levels of improvement: (1) widening only maintaining at-grade intersections and driveways, (2) intermediate upgrade with interchanges at Sanitary Landfill Road, San Antonio Road, and Kastania Road and maintaining most driveways, and (3) full freeway upgrade. Each level of improvement has a cost estimate comprised of the roadway, structures, right of way and engineering costs. Table 4 summarizes the capital costs for each option and variant.

The widening only level does not include right of way costs because the improvements are limited to widening in the existing median only. The intermediate upgrade with interchanges includes costs for right of way required for the three proposed interchanges. The full freeway cost estimate includes the cost estimates developed by Caltrans for their Project Study Report approved in January 1999. The scope of the PSR was limited to upgrading the non-freeway segment of U.S. 101. The total cost for the full freeway level of improvement includes the cost for providing the HOV lanes for the existing freeway segment from Route 37 to north of Atherton Avenue. This cost estimate includes right of way requirements for upgrading the highway portion of U.S. 101 north of Atherton Avenue to a full freeway.

The Design and Construction Engineering costs are assumed to be 25% of the total of the three other categories. This factor is based upon historical data for highways throughout California.

Operations and Maintenance Costs

The operations and maintenance (O&M) costs are based on the same assumptions as those contained in the Sonoma 101 Variable Pricing Report and are summarized in Table

5. Toll lane O&M costs consist of replacement, maintenance, operations and marketing. Replacement costs include items such as computers, AVI equipment and pylons. Maintenance includes those items that do not fall under normal Caltrans roadway maintenance. Operations include CHP enforcement and tolling operations. It could be argued that enforcement should not be included in toll lane O&M costs because CHP routinely monitors HOV lane compliance on other Bay Area freeways. The O&M costs for the toll lanes include a higher level of CHP, which is consistent with other toll lane operations in the state.

All operations costs include staff and special equipment needed by the staff. For example, the police enforcement costs include the salary and benefits of the officer plus their patrol cars. Marketing costs are yearly costs to keep the public aware of the toll lanes. The estimate assumes a higher cost for the first two years and then a constant lower cost for subsequent years. The cost includes a marketing office where consumers can purchase transponders. The HOV options without a toll component do not have marketing costs. Reversible lane options also include staff and equipment replacements costs associated with reversible lane operations.

Toll lane ETC O&M costs, at $1.5 million per year, are only slightly less than those estimated for the longer toll lane alternatives evaluated in the Sonoma 101 Variable Pricing study. The reason is that most of the O&M cost is inherent in setting up and operating any toll collection system, regardless of the length. The cost would be

Table 4: Capital Cost Estimates

		Option A Contiguous HOV Lanes	Option B Contiguous Toll Lanes		Option C Reversible HOV Lane(s)	Option D Reversible Toll Lane(s)	
		No Toll	Permit Toll	Automated Toll	No Toll	Permit Toll	Automated Toll
Widening Only (No Interchanges)	Construction & Right of Way Cost	$48.8	$50.6	$59.6	$53.8	$55.6	$60.1
	Environmental, Engineering & CM	$12.2	$12.7	$14.9	$13.5	$13.9	$15.0
	Total Cost	**$61.0**	**$63.3**	**$74.5**	**$67.3**	**$69.5**	**$75.1**
Intermediate Upgrade (Three Interchanges)	Construction & Right of Way Cost	$67.1	$68.9	$77.9	$72.1	$73.9	$78.4
	Environmental, Engineering & CM	$16.8	$17.2	$19.5	$18.0	$18.5	$19.6
	Total Cost	**$83.9**	**$86.1**	**$97.4**	**$90.1**	**$92.4**	**$98.0**
Full Freeway (Interchanges and Frontage Roads[1])	Construction & Right of Way Cost	$196.1	$197.9	$206.9	$201.1	$202.9	$211.9
	Environmental, Engineering & CM	$49.0	$49.5	$51.7	$50.3	$50.7	$53.0
	Total Cost	**$245.1**	**$247.4**	**$258.6**	**$251.4**	**$253.6**	**$264.9**

1 The construction and right of way costs for the full freeway upgrade were prepared by Caltrans for their Project Study Re on January 29, 1999.

Table 5: Operations and Maintenance Cost Summary

	Option A Contiguous HOV Lanes	Option B Contiguous Toll Lanes		Option C Reversible HOV Lane(s)	Option D Reversible Toll Lane(s)	
		Enforcement[3]	Other O&M		Enforcement	Other O&M
Routine O&M	N/A	N/A	N/A	$140,720[1]	N/A[2]	N/A[2]
Permit Toll Collection	N/A	$318,000	$547,000	N/A	$318,000	$665,750
Automated Toll Collection	N/A	$318,000	$1,205,000	N/A	$318,000	$1,346,000

[1] Routine O&M costs are for switching the reversible lanes.

[2] The routine operations cost for switching the reversible lanes is included in the toll collection costs.

[3] This item could be eliminated if it was decided that routine HOV lane enforcement was suffic ent

reduced to about $1.2 million per year without extra CHP enforcement. A permit toll system would be substantially less that the ETC system at about $505,000 per year. The cost would be reduced to about $130,000 per year without extra CHP enforcement.

The O&M costs vary per year due to the different levels of maintenance as the facility ages. Therefore, the O&M costs have been amortized and converted into a yearly present worth. This means, for example, that the cost for replacing computers every five years has been partly included in O&M cost for each of the first five years, the cost for resurfacing the pavement after ten years is partially included in the yearly O&M cost, etc.

Toll Lane Financial Feasibility

When aggregated to annual values and adjusted for inflation to 1999 dollars, the tolls in Table 6 generate $1.6 million in annual revenue under flat tolling and $1.7 million under variable tolling in 2005. In 2015, these revenues rise to $2.8 and $2.9 million, a growth of 5.37 percent and 5.52 percent per annum, respectively. The net present value of tolls and estimated operating and maintenance expenses are shown along with net operating revenues in Table 6. As the table indicates, the facility generates positive net operating revenues.

The positive net operating revenues can be used to support the construction of the facility. The amount of construction that can be supported by this revenue flow depends upon the rate at which future cash flows are discounted. In Table 7 below, the net present value of net operating revenues is compared with the up-front capital cost requirements, including bond issuance fees. Note that the capital costs presented in Table 7 are higher than the capital costs displayed in Table 4 to account for the assumed five percent debt issuance fee. The capital costs presented are for the intermediate level 2-lane "widening with interchanges", with permit tolling. With the most generous assumed discount rate, net operating revenues support approximately half of the costs for the proposed facility widening, under the assumptions about toll revenue and cost trends described earlier.

<u>Sensitivity Analysis</u>

Table 7 raises several questions that should be addressed in considering the financial feasibility of the proposed project:

- What is the appropriate discount rate to use? From our analysis it is clear that the higher the discount rate assumption, the less financially attractive is the proposed project.
- What would be the effect of continued income growth on the financial feasibility of the project? As income grows, the value of time grows accordingly. As discussed earlier, higher values of time increase the tolerance for tolls approximately proportionately.

The issue of the appropriate discount rate is fairly straightforward. The discount rate should reflect the likely interest rate at which this project can be financed. Even though public projects can be financed through tax-exempt bond issues, which enjoy lower bond rates, economists generally urge that *private* funding rates be employed in evaluating even public projects. The reason is that the lower, public bond rate is achieved through losses in taxable revenue that have to be made up out of higher taxes on private income.

Table 6: Annual Revenues and Costs, 2005-2035 ($m.)

	Revenues (1)		Operating Costs (2)	Net Operating Revenues = (1) -(2)	
Year	*Flat Toll*	*Variable Toll*	*O&M*	*Flat Toll*	*Variable Toll*
2005	$1.6	$1.7	$1.5	$0.1	$0.2
2006	$1.7	$1.8	$1.5	$0.2	$0.3
2007	$1.8	$1.9	$1.5	$0.3	$0.4
2008	$1.9	$2.0	$1.5	$0.4	$0.5
2009	$2.0	$2.1	$1.5	$0.5	$0.6
2010	$2.1	$2.2	$1.5	$0.6	$0.7
2011	$2.2	$2.4	$1.5	$0.7	$0.8
2012	$2.4	$2.5	$1.5	$0.8	$1.0
2013	$2.5	$2.6	$1.5	$1.0	$1.1
2014	$2.6	$2.8	$1.5	$1.1	$1.2
2015	$2.8	$2.9	$1.5	$1.3	$1.4
2016	$2.9	$3.1	$1.5	$1.4	$1.5
2017	$3.1	$3.2	$1.5	$1.6	$1.7
2018	$3.3	$3.4	$1.5	$1.7	$1.9
2019	$3.4	$3.6	$1.5	$1.9	$2.1
2020	$3.6	$3.8	$1.5	$2.1	$2.2
2021	$3.8	$4.0	$1.5	$2.3	$2.4
2022	$4.0	$4.2	$1.5	$2.5	$2.7
2023	$4.3	$4.4	$1.5	$2.7	$2.9
2024	$4.5	$4.6	$1.5	$3.0	$3.1
2025	$4.8	$4.9	$1.5	$3.2	$3.4
2026	$5.0	$5.2	$1.5	$3.5	$3.6
2027	$5.3	$5.4	$1.5	$3.8	$3.9
2028	$5.6	$5.7	$1.5	$4.1	$4.2
2029	$5.9	$6.0	$1.5	$4.4	$4.5
2030	$6.2	$6.4	$1.5	$4.7	$4.8
2031	$6.6	$6.7	$1.5	$5.0	$5.2
2032	$6.9	$7.1	$1.5	$5.4	$5.5
2033	$7.3	$7.4	$1.5	$5.8	$5.9
2034	$7.7	$7.8	$1.5	$6.2	$6.3
2035	$8.1	$8.3	$1.5	$6.6	$6.7
Total	$126.1	$130.0	$47.2	$78.9	$82.8

Note: Revenues have been adjusted for inflation.

Source: ECONorthwest, Parsons Brinckerhoff.

Table 7: Present Value of Revenues, Costs and Net Funding Deficit, 2005-2035 ($m.)

Discount Rate	(1) Revenues		(2) Operating Costs	(3) Net Operating Revenues = (1) -(2)		(4) Capital Cost*	(5) Net Funding Surplus or (Deficit)	
	Flat Toll	*Variable Toll*	*O&M*	*Flat Toll*	*Variable Toll*		*Flat Toll*	*Variable Toll*
	Net Present Value at various Discount Rates							
2%	$85.89	$88.72	$34.93	$50.96	$53.79	$102.27	($51.31)	($48.48)
3%	$71.85	$74.30	$30.46	$41.39	$43.84	$102.27	($60.88)	($58.43)
4%	$60.65	$62.79	$26.79	$33.86	$36.00	$102.27	($68.41)	($66.27)
5%	$51.66	$53.53	$23.75	$27.91	$29.78	$102.27	($74.36)	($72.49)
6%	$44.38	$46.04	$21.21	$23.17	$24.83	$102.27	($79.10)	($77.44)
7%	$38.45	$39.94	$19.09	$19.37	$20.85	$102.27	($82.90)	($81.42)
8%	$33.60	$34.93	$17.29	$16.31	$17.64	$102.27	($85.96)	($84.63)

*Includes construction, ROW and engineering for 2-lane widening project with electronic tolling only. Assumes 5% debt issuance fee in addition to direct capital costs.

However, the relevant discount rate in this case is the *real* discount rate (i.e., the rate that would exist if inflation did not exist) because inflation is implicitly assumed to be zero in the toll and cost analysis. Consequently, a discount rate in the range of 2 percent to 3 percent is not unreasonable; this range corresponds to a nominal discount rate range of approximately 5 percent to 6 percent, for example, if inflation were 3 percent per annum.

The second issue concerns the effect of rising incomes over time. If real incomes rise, then the real value of time will rise, and with it, the optimum level of tolls in real dollars. In Table 8, the analysis of financial feasibility is presented at various assumed level of income growth (i.e., value of time growth). The table uses a fixed, 2 percent real discount rate and zero inflation.[1]

As the table suggests, if real income can be expected to grow at 3% or greater percent per annum or more, the intermediate widening option could be entirely self-financing (i.e., covers both operations and capital costs). At income growth rates below that level, there remains a net funding deficit.

A rate of 3 percent real income growth per annum is optimistic, but not unattainable. From 1994-1997, real personal income in the three locations near the project area, San Francisco, Santa Rosa and Vallejo increased at average annual rates of 3.9, 4.3, 2.5, respectively. However, it is unlikely that the expansion enjoyed in that period will sustain throughout the period we are looking at for this project.

[1] This is equivalent to using a *nominal* discount rate and positive inflation.

Table 8: Sensitivity of the Net Funding Deficit to Income Growth, 2005-2035 ($m.)

Income Growth p.a.	(1) Revenues		(2) Operating Costs	(3) Net Operating Revenues = (1) -(2)		(4) Capital Cost*	(5) Net Funding Surplus or (Deficit)	
	Flat Toll	*Variable Toll*	*O&M*	*Flat Toll*	*Variable Toll*		*Flat Toll*	*Variable Toll*
	Net Present Value at various Growth Rates of Income/Value of Time							
0%	$85.89	$88.72	$34.93	$50.96	$53.79	$102.27	($51.31)	($48.48)
1%	$103.61	$106.91	$34.93	$68.67	$71.97	$102.27	($33.60)	($30.30)
2%	$126.12	$130.00	$34.93	$91.18	$95.07	$102.27	($11.09)	($7.20)
3%	$154.90	$159.52	$34.93	$119.97	$124.59	$102.27	$17.70	$22.32
4%	$191.96	$197.50	$34.93	$157.03	$162.57	$102.27	$54.76	$60.30
5%	$239.98	$246.69	$34.93	$205.05	$211.76	$102.27	$102.78	$109.49

*Includes construction, ROW and engineering for 2-lane widening project with electronic tolling only. Assumes 5% debt issuance fee in addition to direct capital costs.

<u>Summary</u>

The variable rate structure maximizes revenues because it adjusts the toll more closely to the specific conditions of individual links. It is common (on the New Jersey turnpike, for example) for toll rates per mile to vary. In this particular case, because the volumes on the adjacent links do not differ significantly, the flat and variable structures do not generate revenue streams that differ markedly.

From the analysis presented here, the intermediate widening option could be totally self-financing only under very optimistic financial conditions:

- A two percent real discount rate is used.
- Real incomes in the corridor are projected to grow at 3 percent per annum or greater.

If these assumptions are not reached it would not be an unusual circumstance, as most HOV/toll lane-type projects are not self-financing. Fundamentally, the tolled lane “competes” with untolled, adjacent lanes. This limits the tolls that can be set and, consequently, the revenue potential of the facility. However, if a tolled lane that improves traffic flow and person-throughput, improves options for motorists, pays for its own operations, and generates a significant portion of its own capital costs (though less than 100%), then such a project might be deemed feasible as a public policy choice. In such a case, the decision-makers could determine that the net revenues generated would offset some portion of the cost of building the facility, thereby freeing up funds for other worthwhile projects.

APPENDIX

Projected Traffic Volumes

Soutbound A.M.
SR 101 Freeway Segment Volumes, VMT, VHT, Speed, Travel Time, V/C and Person Throughput

Year 2005

Base Case

Segment	Description	Lane Type	Segment Length (mi.)	Lanes	Volume per Lane/hr	Volume	Speed	Time	V/C per Lane	VMT	VHT
1	North of Petaluma	Mixed	1.00	2	1,950	3,900	33.0	1.8	0.98	3,900	119
			-	0	0	0				0	0
2	South of Petaluma	Mixed	7.80	2	2,130	4,260	28.5	16.4	1.07	33,228	1,168
			-	0	0	0	-	-	0.00	0	0
3	South of Atherton A	Mixed	3.60	3	1,822	5,466	34.5	6.3	0.91	19,678	571
			-	0	0	0	-	-	0.00	0	0
4	South of SR 37 (Ex	Mixed	1.00	3	2,302	6,906	22.3	2.7	1.15	6,906	310
		HOV	1.00	1	1,626	1,626	40.6	1.5	0.81	1,626	41
	Total Mixed-Lane Volume				5,902	13,626		24.5		56,806	1,858
	Total HOV Lane Volume				0	0		0.0		0	0
	Totals exclude segment 4		Total			13,626				56,806	1,858

Option A -NB and SB HOV

Segment	Description	Lane Type	Segment Length (mi.)	Lanes	Volume per Lane/hr	Volume	Speed	Time	V/C per Lane	VMT	VHT
1	North of Petaluma	Mixed	1.00	2	2,011	4,022	32.8	1.8	1.01	4,022	123
			-	0	0	0		-	0.00	0	0
2	South of Petaluma	Mixed	7.80	2	1,776	3,552	39.9	11.7	0.89	27,706	694
		HOV	7.80	1	912	912	58.0	8.1	0.46	7,114	123
3	South of Atherton A	Mixed	3.60	3	1,547	4,641	42.7	5.1	0.77	16,708	391
		HOV	3.70	1	1,192	1,192	49.9	4.4	0.60	4,410	88
4	South of SR 37 (Ex	Mixed	1.00	3	2,332	6,996	22.1	2.7	1.17	6,996	317
		HOV	1.00	1	1,711	1,711	38.4	1.6	0.86	1,711	45
	Total Mixed-Lane Volume				5,334	12,215		18.6		48,435	1,208
	Total HOV Lane Volume				2,104	2,104		12.5		11,524	211
	Totals exclude segment 4		Total			14,319				59,959	1,419

Southbound AM Peak Hour Conditions (cont.)

<u>Year 2005</u>

Option B -NB and SB Toll -Time-Variable (Flat per mile) Toll Rate

Segment	Description	Lane Type	Segment Length (mi.)	Lanes	Volume per Lane/hr	Volume	Speed	Time	V/C per Lane	VMT	VHT	Person Throughput
1	North of Petaluma	Mixed	1.00	2	2,051	4,102	31.7	1.9	1.03	4,102	130	4,922
			-	0	0	0		-	0.00	0	0	-
2	South of Petaluma	Mixed	7.80	2	1,845	3,689	37.8	12.4	0.92	28,777	760	4,427
		HOV/Toll	7.80	1	896	896	58.1	8.1	0.45	6,986	120	1,411
3	South of Atherton	Mixed	3.60	3	1,719	5,155	39.2	5.7	0.86	18,559	486	6,187
		HOV/Toll	3.70	1	783	783	59.9	3.9	0.39	2,896	49	1,233
4	South of SR 37 (E	Mixed	1.00	3	2,361	7,083	21.4	2.8	1.18	7,083	331	8,064
		HOV	1.00	1	1,612	1,612	41.0	1.5	0.81	1,612	39	3,587
	Total Mixed-Lane Volume				5,614	12,946		19.9		51,439	1,376	15,536
	Total HOV/Toll Lane Volume				1,679	1,679		11.8		9,881	169	2,644
	Totals exclude segment 4		Total			14,625				61,320	1,545	18,180

Option B -NB and SB Toll -Time/Congestion (Variable per segment) Toll Rate

Segment	Description	Lane Type	Segment Length (mi.)	Lanes	Volume per Lane/hr	Volume	Speed	Time	V/C per Lane	VMT	VHT	Person Throughput
1	North of Petaluma	Mixed	1.00	2	2,051	4,102	31.7	1.9	1.03	4,102	130	4,922
			-	0	0	0		-	0.00	0	0	-
2	South of Petaluma	Mixed	7.80	2	1,894	3,787	36.4	12.9	0.95	29,561	812	4,545
		HOV/Toll	7.80	1	798	798	59.9	8.0	0.40	6,222	106	1,258
3	South of Atherton	Mixed	3.60	3	1,666	4,999	39.6	5.5	0.83	17,996	456	5,999
		HOV/Toll	3.70	1	939	939	57.7	3.8	0.47	3,475	60	1,479
4	South of SR 37 (E	Mixed	1.00	3	2,361	7,083	21.4	2.8	1.18	7,003	331	8,064
		HOV	1.00	1	1,612	1,612	41.0	1.5	0.81	1,612	39	3,587
	Total Mixed-Lane Volume				5,611	12,888		20.2		51,629	1,397	15,466
	Total HOV/Toll Lane Volume				1,737	1,737		11.8		9,697	166	2,735
	Totals exclude segment 4		Total			14,625				61,326	1,563	18,201

SR 101 Freeway Segment Volumes, VMT, VHT, Speed, Travel Time, V/C and Person Throughput (Cont/d)

Southbound AM Peak Hour Conditions

<u>Year 2015</u>

Option A -NB and SB HOV

Segment	Description	Lane Type	Segment Length (mi.)	Lanes	Volume per Lane/hr	Volume	Speed	Time	V/C per Lane	VMT	VHT	Person Throughput
1	North of Petaluma	Mixed	1.00	2	2,423	4,846	32.5	1.8	1.01	4,846	149	4,856
			-	0	0	0		-		0	0	-
2	South of Petaluma	Mixed	7.80	2	1,695	3,390	42.3	11.1	0.85	26,442	627	3,927
		HOV	7.80	1	1,056	1,056	56.5	8.3	0.53	8,237	146	2,350
3	South of Atherton	Mixed	3.60	3	1,570	4,710	42.1	5.1	0.79	16,956	403	5,322
		HOV	3.70	1	1,300	1,300	48.1	4.6	0.65	4,810	100	2,893
4	South of SR 37 (E)	Mixed	1.00	3	2,356	7,068	21.6	2.8	1.18	7,068	328	7,987
		HOV	1.00	1	1,813	1,813	35.6	1.7	0.91	1,813	51	4,024
	Total Mixed-Lane Volume				5,291	12,152		18.0		47,491	1,155	14,015
	Total HOV Lane Volume				2,356	2,356		12.9		13,047	247	5,242
	Totals exclude segment 4	Total				14,508				60,538	1,402	19,257

Option B -NB and SB Toll -Time-Variable (Flat per mile) Toll Rate

Segment	Description	Lane Type	Segment Length (mi.)	Lanes	Volume per Lane/hr	Volume	Speed	Time	V/C per Lane	VMT	VHT	Person Throughput
1	North of Petaluma	Mixed	1.00	2	2,058	4,116	31.5	1.9	1.03	4,116	131	4,939
			-	0	0	0		-	0.00	0	0	-
2	South of Petaluma	Mixed	7.80	2	1,861	3,722	37.4	12.5	0.93	29,032	776	4,466
		HOV/Toll	7.80	1	823	823	58.6	8.0	0.41	6,419	110	1,296
3	South of Atherton	Mixed	3.60	3	1,759	5,277	37.1	5.8	0.88	18,997	512	6,332
		HOV/Toll	3.70	1	920	920	57.9	3.8	0.46	3,404	59	1,449
4	South of SR 37 (E)	Mixed	1.00	3	2,408	7,224	20.4	2.9	1.20	7,224	354	8,163
		HOV	1.00	1	1,768	1,768	36.8	1.6	0.88	1,768	48	3,934
	Total Mixed-Lane Volume				5,678	13,115		20.2		52,145	1,419	15,738
	Total HOV/Toll Lane Volume				1,743	1,743		11.9		9,823	168	2,745
	Totals exclude segment 4	Total				14,858				61,968	1,587	18,483

Option B -NB and SB Toll -Time/Congestion (Variable per segment) Toll Rate

Segment	Description	Lane Type	Segment Length (mi.)	Lanes	Volume per Lane/hr	Volume	Speed	Time	V/C per Lane	VMT	VHT	Person Throughput
1	North of Petaluma	Mixed	1.00	2	2,058	4,116	31.5	1.9	1.03	4,116	131	4,939
			-	0	0	0		-	0.00	0	0	-
2	South of Petaluma	Mixed	7.80	2	1,877	3,754	36.9	12.7	0.94	29,281	794	4,505
		HOV/Toll	7.80	1	791	791	58.9	8.0	0.40	6,170	105	1,246
3	South of Atherton	Mixed	3.60	3	1,743	5,229	37.5	5.8	0.87	18,824	502	6,275
		HOV/Toll	3.70	1	969	969	57.4	3.9	0.48	3,585	62	1,626
4	South of SR 37 (E)	Mixed	1.00	3	2,408	7,224	20.4	2.9	1.20	7,224	354	8,163
		HOV	1.00	1	1,768	1,768	36.8	1.6	0.88	1,768	48	3,934
	Total Mixed-Lane Volume				5,678	13,098		20.3		52,222	1,426	15,719
	Total HOV/Toll Lane Volume				1,760	1,760		11.8		9,755	168	2,772
	Totals exclude segment 4	Total				14,858				61,977	1,592	18,491